Mars Observer Mission Plan

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Plans are described for operating the Mars Observer mission. These have been developed to help reverse the trend toward increasing compexity in operating interplanetary spacecraft. The normal data return strategy uses continuously recorded data with a single daily playback through the Deep Space Network. Although the mission has been planned with constrained data return strategies and modest data rates, it will still provide, both in temporal and spatial coverage and resolution, the most comprehensive study of an extraterrestrial planet to date.

Introduction

THE Mars Observer mission will deliver a single spacecraft to Mars for an extended orbital study of the planet's surface, atmosphere, and gravitational and magnetic fields. Achieving the scientific objectives of the mission for a better understanding of the geology, geophysics, and climatology of Mars will require delivering the spacecraft to a low-altitude, near-polar orbit and returning data from the scientific payload over a complete Martian year. The scientific payload for Mars Observer is made up of six instruments, and a seventh investigation, radio science, collects data at a ground station of the Deep Space Network (DSN) from the spacecraft radio signal. This paper describes plans for operating the spacecraft over the three-year mission. The initial mission and system concept for Mars Observer was defined in 1984.[1] Companion papers in this issue give an overview of the current mission and system concept[2] and describe the trajectory design[3] and the spacecraft.[4]

A time line for the three-year mission is shown in Figure 1. The spacecraft will be launched during the Mars opportunity of September/October 1992. Arriving at Mars in August 1993, the spacecraft will be inserted into an initial elliptical orbit, which facilitates transition of the orbit plane to the desired solar orientation. Over a period of about four months in a sequence of seven planned maneuvers, the spacecraft will be maneuvered into the mapping orbit, which is nearly circular at low altitude and Sun-synchronous at the desired solar orientation of 2 p.m. at the dayside descending node. Repetitive observations of the planet's surface and atmosphere will be conducted from the mapping orbit for a complete Martian year (687 Earth days). The final spacecraft configuration, which is established after reaching the mapping orbit, is shown in Fig. 2. The spacecraft will maintain a nadir orientation in the mapping orbit. There will be no scan platform, and any scanning capability will be provided by the instruments. The mapping orbit will have a repeating groundtrack that allows global coverage to be built up from repeated instrument swaths. All communication between the spacecraft and the ground, including commanding and science and engineering telemetry, will be at X-band frequencies. The normal sequence of collecting science data will be to record it continuously for about 24 h, and then play it back through the DSN in one tracking station pass on each day. Approximately every third day an additional tracking pass will be scheduled to return high-rate, real-time data. The period of science observations (the mapping phase) extends from December 1993 to November 1995. NASA is planning for Mars Observer to provide a data relay for a Soviet mission to Mars to be launched in 1994 and to arrive at the planet in September 1995.

Five mission phases define different periods of activity during the mission. These are the launch, cruise, orbit insertion, mapping, and Mars 1994 support phases. Two time epochs are useful for defining activities and the boundaries of some of the mission phases. Launch L is the time of liftoff of the launch vehicle. Mars orbit insertion (MOI) is the time at which the spacecraft begins the propulsive maneuver to brake into orbit about Mars.

Launch Phase

The launch phase extends from the start of the launch countdown until separation of the spacecraft from the transfer orbit stage (TOS) upper stage after the injection maneuver. The timing and sequence of spacecraft operations in this phase are dictated by the launch profile of the Titan launch vehicle and the TOS upper stage and will be controlled by the spacecraft flight software.[2] At the end of the injection burn, the TOS upper stage turns to point the spacecraft into a favorable attitude relative to the Sun for power and thermal control and relative to the Earth for telecommunications. Prompt initial acquisition of the spacecraft telemetry after launch is a critical event for establishing ground monitoring and control of the spacecraft. The Titan launch trajectories provide favorable geometry for early DSN acquisition over the Canberra, Australia, tracking site.

Cruise Phase

The cruise phase is the period of transit from Earth to Mars lasting about 11 months. This mission phase begins when the spacecraft separates from the TOS and ends at the beginning of the orbit insertion sequence at Mars. A cruise phase time line based on the earliest injection date of Sept. 16, 1992, is shown in Fig. 3. The 20-day launch period extends from Sept. 16 through Oct. 5, 1992. The corresponding arrival dates at Mars are between Aug. 19 and Sept. 6, 1993. The primary activities during the cruise phase are initial deployment and checkout of the spacecraft into its cruise configuration, daily monitoring of the subsystems, navigation activities to determine and correct the flight path to Mars, and limited science calibration measurements. The spacecraft cruise configuration is shown in Fig. 4.

The cruise phase is divided into two subphases, based on pointing of the spacecraft. During the inner cruise subphase, lasting until Jan. 3, 1993 (L + 109 days for the first launch

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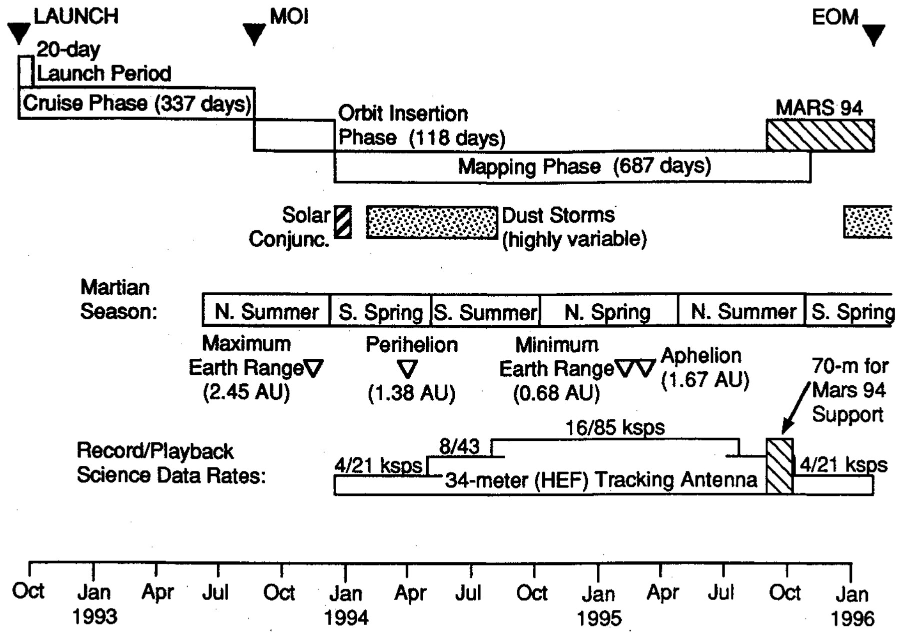

Fig. 1 Mars Observer mission time line (AU, astronomical unit; EOM, end of mission).

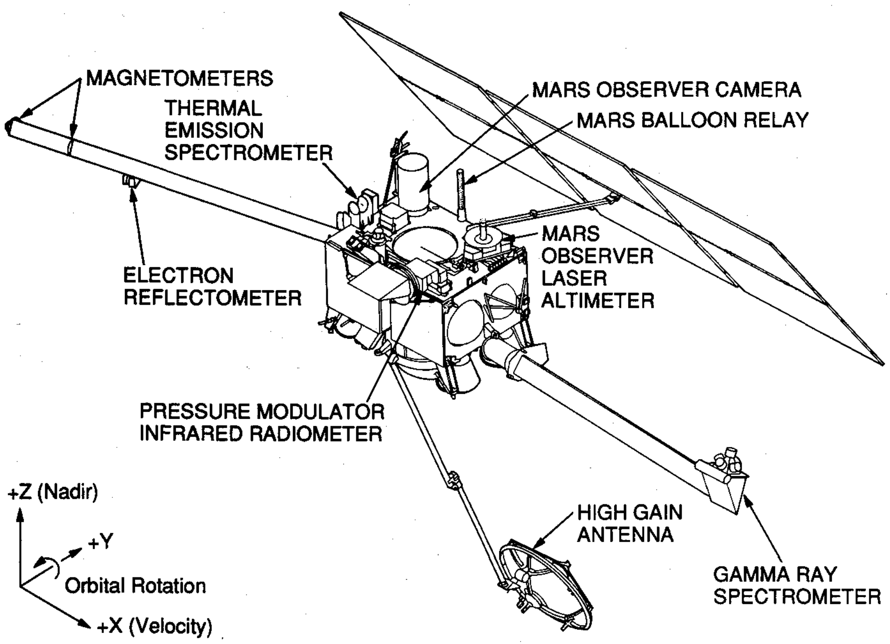

Fig. 2 Spacecraft mapping configuration.

date), the spacecraft solar panels cannot be pointed too close to the Sun to limit the power input, which would otherwise overload the shunt regulator. Communications during inner cruise will be through the low-gain antennas (LGAs). During the outer cruise subphase, as it moves farther from the Sun, the spacecraft will be Earth-pointed and will use the high-gain antenna (HGA) for communication. The HGA is not articulated in the cruise configuration. Four trajectory correction maneuvers (TCMs) are planned during the cruise phase to correct the interplanetary trajectory to achieve the proper arrival conditions at Mars.

Inner Cruise Subphase

Separation from the upper stage will occur about 12.5 min after the injection burn by the single-stage, solid-propellant TOS. The spacecraft will just be rising over the Canberra tracking site. After separation from the TOS, the spacecraft will partially deploy the solar panels and the HGA into the cruise configuration. Four of the six solar panels are unfolded parallel to the $+Y$ face of the spacecraft, and the HGA boom is partially deployed so that the antenna has a clear field of view over the panels, normally pointing in the $+Y$ direction. The cruise attitude mode has the spacecraft pitching slowly (0.01 rpm) about the Y axis so that the celestial sensor acquires star transit data to maintain the inertial reference.

Initially, the spacecraft will maintain the inertial attitude provided by the TOS and will transmit at a real-time engineering rate. Initial acquisition at the Canberra tracking site is expected within 30 min after the transmitter is turned on, and the actual time will probably be much less. Doppler tracking data will be collected to update the spacecraft ephemeris, and the ground will monitor real-time engineering telemetry to assess the health of the spacecraft and to verify the initial deployments. Two hours after separation, the spacecraft will begin its attitude initialization sequence. To establish a three-axis attitude reference, the spacecraft must scan the celestial sensor around the sky to identify known stars. At an appropriate time after acquisition, playback of recorded engineering data from the launch phase will be commanded from the ground. The final step in configuring the spacecraft is extension of the gamma-ray spectrometer (GRS) and magnetometer/electron reflectometer (MAG/ER) science booms into the cruise deployment positions.

A major constraint during this period is use of the LGAs for communication. As shown in Fig. 3, the available data rate drops to 250 bps (bits per second) as the spacecraft moves away from the Earth. The principal engineering activities during inner cruise are the initial deployment and checkout of the spacecraft, support for TCM-1, and support for a period of science instrument checkout and calibration after TCM-1. The first days after injection are reserved for checkout of the spacecraft after launch. There are no special checkout procedures, but this will be a period of intensive monitoring of each subsystem. A period of three days from $L+15$ to $L+18$ days is reserved for TCM-1 activities. The period from $L+18$ to $L+30$ days is currently allocated for payload health checks and calibrations. There will be adequate power in this period to turn on the payload data subsystem (PDS) and individual instruments to determine that they have survived launch. Calibrations of the GRS and MAG/ER are required early in cruise to make spacecraft background measurements, and these will be scheduled between TCM-1 and $L+30$ days, when higher data rates are available and there is continuous DSN coverage.

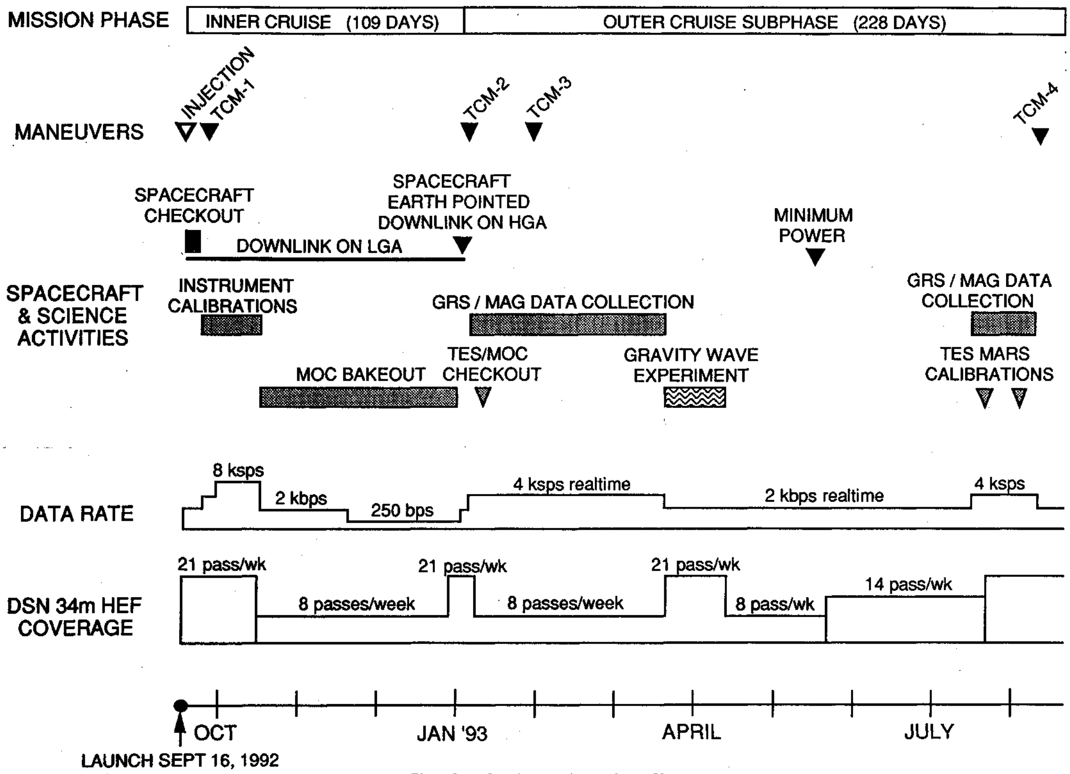

Fig. 3 Cruise phase time line.

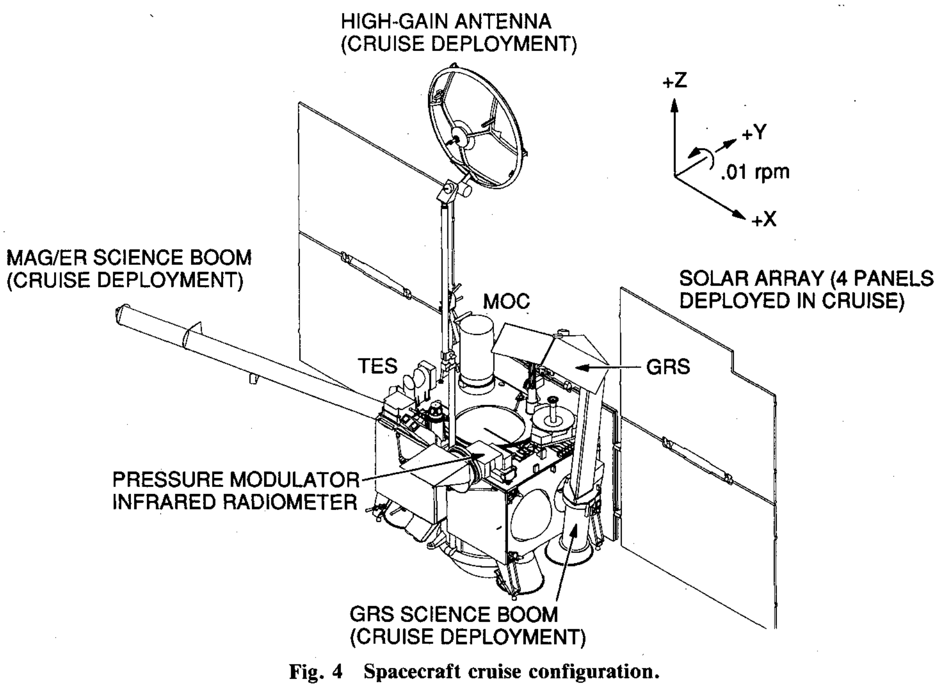

Fig. 4 Spacecraft cruise configuration.

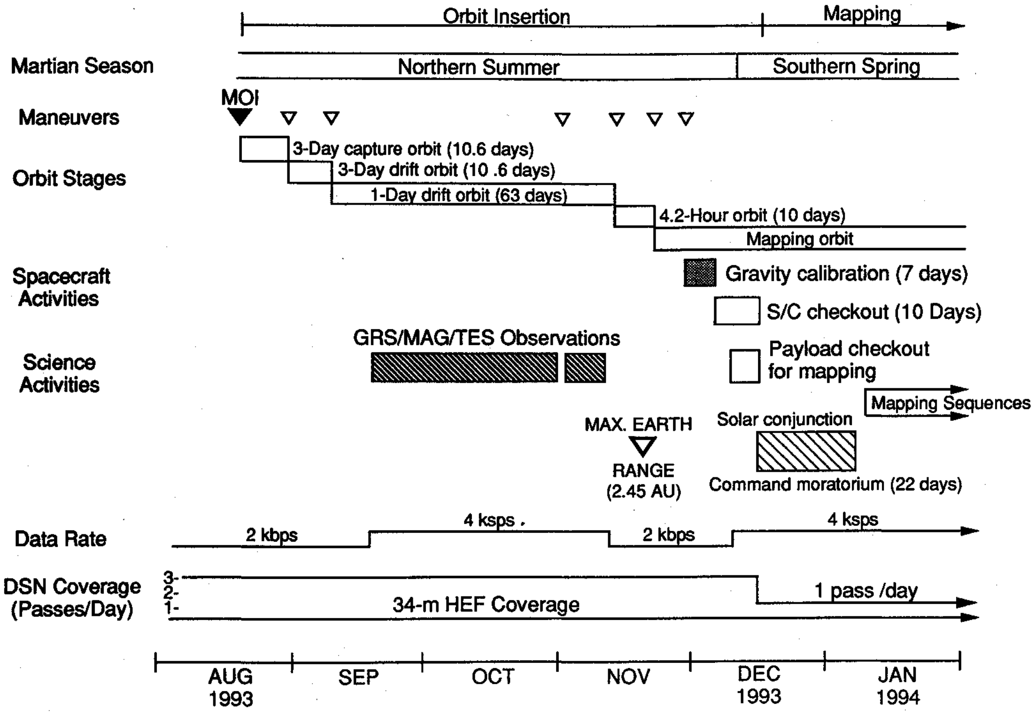

Fig. 5 Orbit insertion phase time line.

Outer Cruise Subphase

When the spacecraft is far enough from the Sun in early January 1993, it can be pointed to the Earth without power or thermal constraints, and communications can be switched to the HGA at higher data rates. This begins the outer cruise subphase, which continues to MOI. Three TCMs are scheduled in outer cruise as shown in Fig. 3. Two periods of science instrument data collection are scheduled at the beginning and end of outer cruise; there are no payload activities in between because the available solar array power reaches a minimum in May 1993. The most intensive period of operations will be the last days leading up to MOI, including the last period of payload cruise data collection and TCM-4 at MOI-15 days.

Orbit Insertion Phase

The orbit insertion phase is the period of transition from the interplanetary trajectory to the mapping orbit around Mars. This cannot be done efficiently in one maneuver and, to meet all of the constraints, a series of seven orbit insertion maneuvers is planned.[3] This phase extends from the beginning of the MOI sequence until the spacecraft is established in the mapping orbit and declared ready to begin science data collection. The focus of activity during this phase will be the planning and execution of the orbit insertion maneuvers. There will be limited science activity when the spacecraft is in an intermediate elliptical orbit, the drift orbit, which is used to achieve transition to the 2 p.m. solar orientation. Near the end of this phase, before deploying into the mapping configuration, the spacecraft will be operated for one week in the mapping orbit to return an initial Doppler data set for refining the gravity model for Mars. Following this gravity calibration period, a spacecraft checkout period of up to 10 days is planned before beginning the mapping phase. During this checkout period, the spacecraft will be deployed into the mapping configuration, the scientific payload will be activated, and tests will be performed of both the spacecraft and the ground system.

Figure 5 shows a time line for the orbit insertion phase, based on the earliest launch date. A series of seven maneuvers are executed over a period of up to four months, depending on launch date, to maneuver the spacecraft from the approach trajectory to the mapping orbit. Table 1 gives the start and end dates for the mission phases for the earliest and latest launch dates.

Table 1 Start and end dates for mission phases

	Earliest launch date	Latest launch date
Launch date	Sept. 16, 1992	Oct. 5, 1992
Cruise phase duration	337 days	335 days
Mars orbit insertion	Aug. 19, 1993	Sept. 5, 1993
Orbit insertion duration	118 days	97 days
Begin mapping phase	Dec. 16, 1993	Dec. 11, 1993
Mapping duration[a]	687 days	687 days
End mapping phase	Nov. 3, 1995	Oct. 29, 1995

[a]Mapping phase duration includes 22-day command moratorium during solar conjunction; there may be limited scientific data return during this period.

Drift Orbit Science Activity

Except during maneuvers, the spacecraft will maintain the outer cruise attitude with the $+Y$ axis pointed to the Earth until it reaches the mapping orbit. Although the orbit insertion phase was not originally planned for it, valuable scientific data can be collected during this period, in particular, unique observations from the drift orbit. Data collection by the MAG/ER, GRS, and the thermal emission spectrometer (TES) are scheduled in periods between maneuvers in the drift orbit. Because there will be continuous tracking of the spacecraft in the drift orbit for navigation purposes, these data can be returned in real time without operating the tape recorders. Magnetometer observations from the drift orbit will permit unique measurements of the interface between the solar wind and the Martian environment, which will not be observable from the low-altitude mapping orbit. GRS observations from the drift orbit will provide valuable calibration data at varying distances from the planet.

Gravity Calibration Period

After the mapping orbit is reached, deployment into the mapping configuration will be delayed for a 7-day gravity calibration period, during which the DSN will collect a continuous Doppler data set, except during occultations. This data set will provide the first global coverage of the gravity field at low altitude. It will be used by the navigation team to make a first update to the gravity field model to improve prediction and reconstruction of the spacecraft ephemeris early in the mapping phase. The mapping orbit provides a groundtrack pattern that nearly repeats in 7 Martian days (7 sols = 7.2 Earth days), providing uniform coverage of the planet with a maximum groundtrack spacing at the equator of about 240 km. This provides good resolution for the gravity field solutions. The gravity calibration period is scheduled after the last orbit insertion maneuver, which will correct errors in the mapping orbit. The spacecraft will remain in the cruise configuration during the gravity calibration period, rotating slowly about the Earth-pointed $+Y$ axis. This configuration will minimize HGA disturbances that could degrade the Doppler measurements. Transmissions from the spacecraft will be autonomously cycled off during the solar eclipse period on each orbit, which nearly overlaps the Earth occultation period. This reduces battery discharge, which is constrained when only four solar panels are available for recharging.

Spacecraft Checkout

A period of up to 10 days at the end of the orbit insertion phase has been reserved for deployment and checkout of the spacecraft into the mapping configuration, before the start of the mapping phase is declared. This period will also include final readiness tests with the ground system and operations teams. After reaching the mapping orbit, the HGA boom and the six-panel solar array and its boom will be fully deployed to the mapping configuration. The spacecraft will then autonomously acquire the nadir orientation. Full extension of the MAG/ER boom and further partial extensions of the GRS boom are the final steps in configuring the spacecraft for the mapping phase, as shown in Fig. 2. The GRS will be calibrated with its boom in two intermediate positions before full extension. After the PDS and instruments are powered and their memories loaded, an initial mapping sequence will be executed on the spacecraft to verify readiness for mapping.

Mapping Phase

The mapping phase is the period of concentrated science return from the mapping orbit. It begins when the spacecraft is delivered to the mapping orbit and declared ready for the collection of science data and extends for one Martian year (687 Earth days). Table 1 gives dates for the start and end of the mapping phase showing the variation between the first and last launch dates. The mapping phase now starts very close to solar conjunction, and the project hopes to advance this date by using any excess propellant to shorten the orbit insertion phase. Reference 3 describes this design option. The end of the mapping phase now overlaps by about two months the initial orbital activities of the Soviet Mars 1994 mission. NASA is planning for Mars Observer to provide a data relay from surface stations and penetrators deployed by the Soviet mission.

Spacecraft operations in the mapping orbit will be very repetitive. The six-panel solar array and the HGA are deployed on separate booms and gimballed in two axes to track the Sun and the Earth, respectively, around each 117-min orbit. In the primary attitude control mode, data from the horizon sensors and the inertial measurement unit are used to point the science platform on the $+Z$ panel to the nadir and the $+X$ axis in the direction of orbital motion. A backup control mode is available to point the spacecraft using data from the celestial sensor and an ephemeris prediction loaded from the ground.

Pointing of the spacecraft is maintained by the momentum wheels. Due to atmospheric drag, gravity gradient, and solar pressure torques, momentum in the wheels will build up and must be periodically unloaded by thruster firings. This is an autonomous spacecraft function. Periodic orbit trim maneuvers will be commanded from the ground to maintain the predicted timing and groundtrack pattern of the mapping orbit. These are scheduled every two weeks, as required, to offset orbit perturbations, principally atmospheric drag.

Data Collection Strategy

There will be two modes for collecting science data. The primary mode provides continuous data collection from the six science instruments. Data are continuously recorded on the tape recorders and played back to Earth during the daily tracking station pass. The secondary mode is to return real-time, high-rate telemetry at the 40-ksps rate during additional tracking passes, normally scheduled once every third day. Only two instruments, the TES and the Mars Observer camera (MOC) return data in this real-time mode. All science data streams are Reed-Solomon encoded, resulting in 1000 encoded bits or "symbols" for every 872 bits of data collected by the PDS. The PDS output is the encoded bit stream, usually described by the rate in kilosymbols per second (ksps). Science data will normally be returned through the DSN's new subnetwork of 34-m, high-efficiency (HEF) tracking antennas, which operate at X-band frequencies for both uplink and downlink telemetry. Data return through these antennas, which are located at Goldstone, California, and near Canberra, Australia, and Madrid, Spain, was planned to avoid the competition for the DSN's largest 70-m antennas. This was also consistent with the mission's more modest data rates.

Recorded Data Return

The basic strategy for collecting science data during the mapping phase is to record it on one tape recorder (sometimes two) for 24 h and then play it back in one DSN tracking pass on each day. With three tape recorders and appropriate record and playback rates, data can be collected continuously and only one tracking pass is required on each day. Three pairs of record and playback rates have been defined for this normal mode of operation. The playback rates are 21.3, 42.7, and 85.3 ksps, and the corresponding record rates are 4, 8, and 16 ksps. The 48:9 ratio between the playback and record rates was selected because in a typical 8-h DSN tracking pass, due to Earth occultations, a minimum playback time of roughly 4.5 h is available to return 24 h of recorded data. The playback rates were selected to cover the range of expected telecommunications capability as the Earth-to-Mars distance varies over the mapping phase. Each of the three tape recorders on the spacecraft can store up to 48 h of data at the 4-ksps record rate and up to 12 h at the 16-ksps rate.

Figure 1 shows an estimate of the usage of the three standard record rates over the mapping phase. The availability of the playback rates has been estimated at the three stations of the 34-m (HEF) subnet. The data rate profile shown is based on the capability to return 24 h of recorded data over at least one station of the subnet and, in most cases, at least two stations. Except for early in the mapping phase, when Mars is at southern declination and seen most favorably from the Canberra site, the data rate profile shown allows a choice between at least two stations to avoid tracking conflicts with other missions. Early in the mapping phase the tracking passes at Goldstone and Madrid are too short to allow a full playback to a 34-m (HEF) antenna.

Because the spacecraft goes into occultation on each revolution in the mapping orbit, the playback must be broken into segments and sent down over more than one orbit. Typical playbacks will be made in four or five segments, depending on the playback time available on each orbit and the relative timing between the occultation events and the DSN tracking pass. The available playback time on each orbit is determined by the orbit period; minus the time the spacecraft is in Earth occultation; minus the time allocated for the radio science experiment, DSN lock-up time, and any navigational uncertainty. This is illustrated in Fig. 6, which shows a typical orbit profile.

The mapping orbit has a period of 117.65 min and the time in Earth occultation is typically about 40 min (maximum of 41.6 min). Some additional time when the spacecraft is entering and exiting occultation will be used for the atmospheric occultation experiment. The radio science requirements are to record occultation data at a ground station, from the surface to an altitude of 200 km plus 100 s, for every ingress and egress event that occurs during a tracking pass. Because telemetry modulation will be turned off for this experiment for maxi-

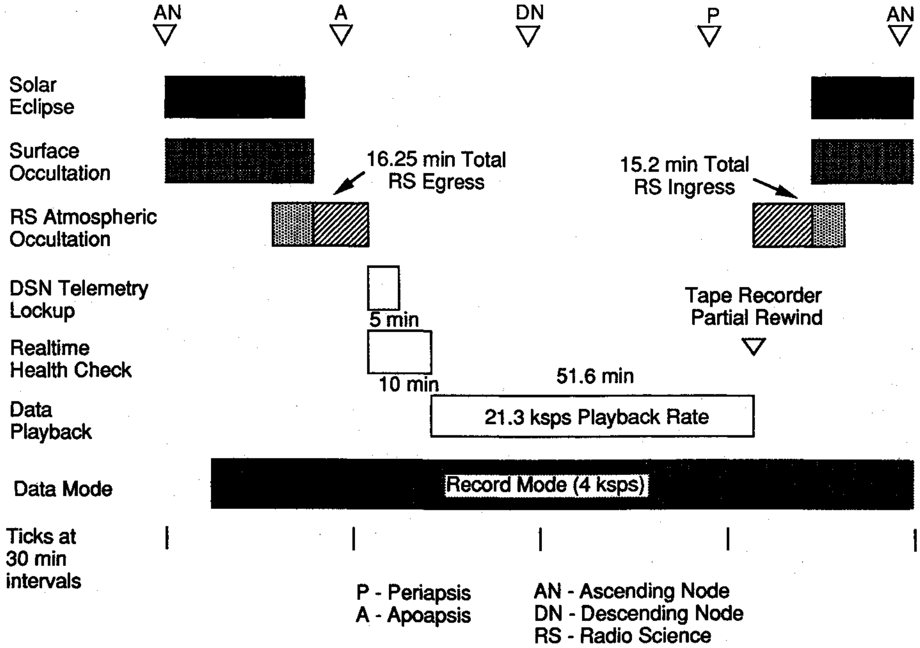

Fig. 6 Typical profile for playback orbit.

mum signal strength, the duration of this experiment subtracts from the available playback time. Over about the first 400 days of the mapping phase, the occultation experiment will typically require 9–10 min/orbit. If the tape recorder playback is returned over parts of four orbits, radio science will require typically 35–40 min of dedicated transmitter usage over this period. Later in the mapping phase the atmospheric occultations are longer in duration, but the total occultation time (surface plus atmosphere) is shorter, and the available playback time per orbit increases.

As the spacecraft comes out of occultation on each orbit, the DSN will require a maximum of 5 min on the first observed orbit and 1 min on each subsequent orbit to lock up the telemetry stream. Telemetry modulation is turned on after the radio science egress observation. The navigational uncertainty in the timing of orbital events must also be considered in deciding when to begin the playback segment on each orbit. The orbit trim maneuvers will be used to control the timing uncertainty for equator crossing events over the mapping phase to be no greater than 2 min at 99% confidence. This same uncertainty will apply to most orbital events, once orbit timing control is established six weeks after the solar conjunction period.

Real-time spacecraft status or health checks are desirable at the beginning of a playback pass to immediately advise the ground monitoring teams of any problems that would otherwise only be detected by reviewing the playback of the data recorded on the previous day. In the reference case described next, 10 min of real-time telemetry has been included at the beginning of each playback pass, primarily as a "pump primer" during the 5 min (worst case) of DSN lock-up time on the first orbit. This provides real-time telemetry for the ground monitoring teams, with enough data for at least one sample of each engineering channel.

The duration of the tracking pass that is required to support a complete playback of the tape recorder will also depend on the timing of the orbit relative to the beginning of the tracking pass. In the worst case, the tracking pass would begin just as the spacecraft entered occultation, and playback would be delayed for about 40 min. In the best case, the spacecraft would be exiting occultation at the beginning of the pass, and a full segment of the playback could be made immediately. The data rate profile shown in Fig. 1 assumes the worst-case timing of the occultations relative to the start of a tracking pass.

Real-Time Data Return

The project has included a real-time data rate of 40 ksps (34.9 kbps) to permit the return of some high-bandwidth data that would otherwise be constrained to the lower record rates. The project policy is that an additional tracking pass will be scheduled approximately every three days over the mapping phase to return data at the real-time rate. This additional real-time data returned every three days augments the recorded data returned every day at the available playback rate. The 40-ksps rate can be returned at the 34-m (HEF) antennas over most of the mapping phase, and only a brief period of 70-m tracking support is required in January and February 1994, when Mars is farthest from the Earth.

A strategy for collecting the real-time data adds some complexity to the mission design. The recorded data modes provide complete coverage over each orbit and around the planet on each mapping cycle. However, the real-time data can only be collected when the Earth is in view, that is, primarily on the dayside of the planet, and when an additional tracking pass is scheduled. Only data from TES and MOC, along with spacecraft engineering data, will be returned during real-time coverage.

Mapping Reference Case

To illustrate typical activities for data return during the mapping phase, a reference case is described for a day late in January 1994, when science data will be collected at the lowest record rate of 4 ksps. Mars is near maximum distance from the Earth and also near maximum southern declination, and the tracking passes at Goldstone and Madrid are too short for complete playbacks. On this date, only the 21.3-ksps playback rate, corresponding to the 4-ksps record rate, will be returned at the 34-m (HEF) antennas. The Earth occultation time on this date is 37.8 min. With the assumption of worst-case orbit timing and higher orbit prediction errors of up to 5 min early in the mapping phase, this requires a tracking pass duration of 9.5 h to return a complete playback. A maximum of 61.6 min of playback time will be available on each orbit. The tracking time available at the Goldstone or Madrid 34-m (HEF) antennas will be too short to support the playback during this period, and playbacks will normally be scheduled at Canberra, where the tracking time available is 11.8 h.

Figure 7 shows a typical activity time line for this date with the data playback being made to Canberra. Data are recorded continuously in the 4-ksps data mode with a single recorder being used for 24 h. Data recorded on the previous day are

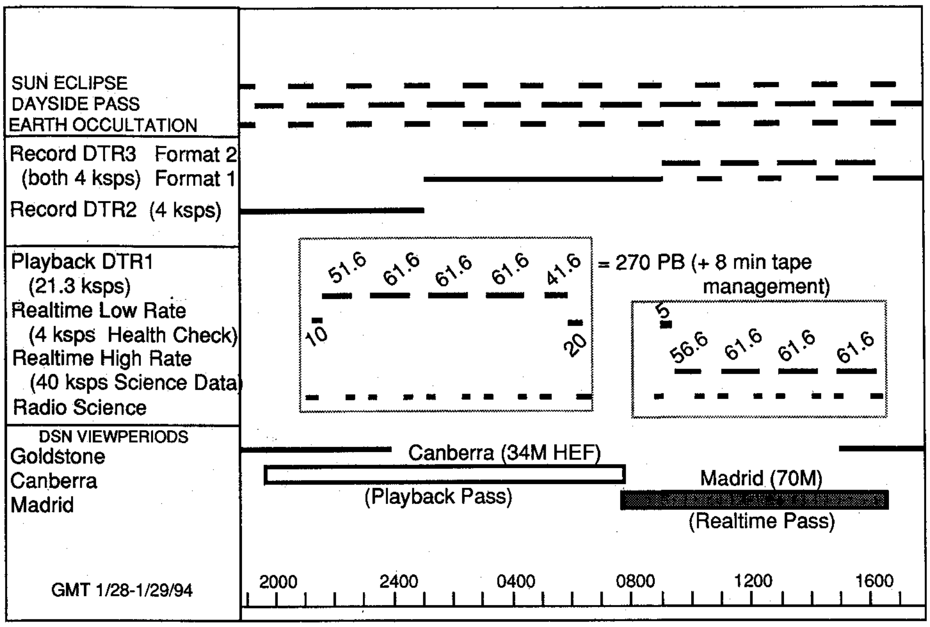

Fig. 7 One-day activity time line for mapping reference case Jan. 28–29, 1994 (DTR, digital tape recorder).

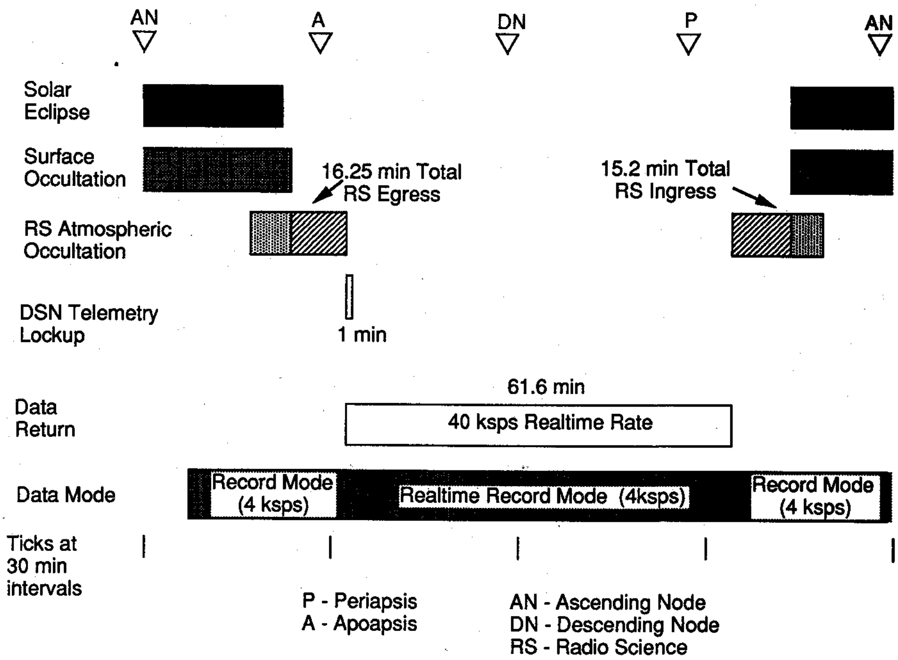

Fig. 8 Typical real-time orbit profile.

played back over five orbits. Coverage time at Canberra allows data return on a fifth orbit, and this is shown in a real-time telemetry mode, which is useful for spacecraft monitoring. Figure 6 shows an activity time line for the first playback orbit. Between the Earth occultation events and the radio science atmospheric occultation events at egress and ingress, 61.6 min of telemetry return time are available. On the first playback orbit, up to 5 min may be required for DSN lockup. Real-time engineering data are returned for the first 10 min, and this provides engineering data for the ground monitoring teams. Following this, 51.6 min of tape recorder playback can be made before the radio science ingress observation. On subsequent orbits, the DSN lock-up time is only 1 min, and up to 61.6 min of playback data can be returned.

Figure 7 shows an example of an additional 70-m pass on the reference date for 40-ksps real-time coverage. The additional pass at Goldstone allows real-time data return on portions of four orbits; Fig. 8 shows an orbit profile for the real-time coverage. The PDS switches to a real-time data mode to return high-rate data from MOC and TES and in this mode continues to send a 4-ksps data stream to a recorder. In this case, real-time telemetry is turned on for the full 61.6 min between the radio science occultation observations to maximize the data return. Some data will be lost during DSN lockup, but this occurs before the spacecraft crosses the terminator to the dayside, where MOC imaging begins. Real-time data return continues past the terminator crossing to the nightside, until the radio science ingress observation.

Mars 1994 Support Phase

Mars Observer will carry a data relay system supplied by the French national space agency (Centre National d'Etudes Spatiales) to support data return from surface stations deployed by the Soviet Mars 1994 mission. This is the Mars Balloon Relay (MBR), which was originally intended to return data from balloons deployed into the Martian atmosphere. Specific requirements for operating the MBR in cooperation with the Mars 1994 mission will be defined from agreements reached by a trilateral working group, the Implementation/Operations Working Group, composed of U.S., French, and Soviet representatives. The Soviet Mars 1994 mission will consist of a single orbiter spacecraft launched in October 1994 that will arrive at Mars in early September 1995 and be inserted into an elliptical orbit around the planet. About seven days before reaching the planet, the orbiter will release the surface stations to different locations on the planet. As currently understood, the surface stations will consist of two landers and two penetrators with science instrumentation.

Data will be stored on the surface stations, and then sent up to either Mars Observer or to the Mars 1994 orbiter during brief contact periods on each day, and subsequently relayed to Earth. Data transmissions to Mars Observer will be initiated by the MBR downlink signal when the spacecraft passes close enough to the station, typically for periods of no more than 11 min. There will be at least two of these contact periods a day, once in the afternoon at about 2 p.m. local time and again at night at about 2 a.m. The MBR receives the data, adds engineering data of its own, including Doppler measurements for localization, and sends the data directly to the Mars Observer camera for storage in the MOC buffer. MOC will read the MBR data out of its buffer in the same manner as imaging data and return it in the normal recorded data stream, or the real-time data stream during real-time DSN passes.

Conclusion

Plans for operating the Mars Observer mission have been developed to a substantial level of detail. These will be used to plan detailed sequencing strategies for the mission. Although the mission has been planned with constrained data return strategies and modest data rates, the low-altitude orbit and full Martian year of observations will still provide, both in temporal and spatial coverage and resolution, the most comprehensive study of an extraterrestrial planet to date.

Acknowledgment

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